THE ATHENS AIR TRAFFIC CONTROL TOWER – A CASE OF A SICK BUILDING

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ABSTRACT

It is well understood that there are many sick professional buildings in use all over the world. Most of them are sited in or near the center of large cities where the ambient atmospheric conditions are not good. The sickness syndrome of those buildings combines both the indoor air quality and the local comfort regime. In many cases the responsibility for the formation of these syndromes lies with the not appropriate envelope design and the misuse of the building by the inhabitants. In the case of the Athens Air Traffic Control Tower, (ATCT), many sick syndrome cases were reported by the employs. In the present study, recently obtained indoor air quality estimates taken in the ATCT, will be presented and discussed in an attempt to face the problems reported by the building users. In this respect air quality measurements during selected meteorological conditions were taken. These include concentrations of Volatile Organic Compounds, which in many cases have been considered responsible for bad indoor environments. The air samples were collected by suitable absorbing elements that were analysed in an advanced chemical laboratory equipped with the appropriate instrumentation for the determination of the VOC's. The measurements cover the indoor environment of selected building arias, the ventilation systems and the plenum under the floor. The data indicate that there are certain places in the building where the VOC's concentrations were well above outdoor levels while in other the concentrations were reasonable. Deeper analysis of the results showed that both the central ventilation system is not sufficient for the building needs and that in some areas either dew to cleaning negligence or to the construction material used, VOC's pollution sources have developed.

INTRODUCTION

In the recent years indoor air quality in buildings has been the topic of research of many working groups. This can be explained by the fact that human beings spend the 90% of their life indoors where many problems developed as a result of the careless man-made interference to the indoor environment. A typical example of such interference is the closure of all openings for energy saving purposes, the use of untested new construction materials, the furniture as well as the bad air exchange. As a result of this interference is the increase of many chemical substances such as the Volatile Organic Compounds, VOC's, formaldehydes, asbestos and many others, (see e.g. Lagoudi et al.,95 and 96a, b). In general the air quality in airport buildings presents certain specific characteristics in comparison to the conventional professional and private cases. This is mainly caused by the specific nature of both building design and pollution sources. In fact for the airport case of buildings the main sources of pollution are external where significant local emissions normally prevail. These include, aircraft operation, local car traffic, fuel transportation and storage, and aircraft servicing. Especially during the take off and landing of the aircraft, significant amount of VOC's are emitted mainly because of the incomplete kerosene burning. Further more, internal building spaces are quite large with many users that produce a variety of pollutants, (e.g. smoking, operation of electronic instruments, restaurants, toilets etc). It should be mentioned here that in the present case, the complete airport operations were shifted to the new site at Spata. The remaining services were the ATCT block and certain facilities that would be removed at a later stage, (e.g. kerosene large storage reservoirs, small aircrafts and other local airport agents).

The determination of the air exchange rate, the recycling percentage, the selection of filters and the ventilation system maintenance, should be carefully chosen taking into consideration all specific parameters. In general for the large airport cases, acceptable indoor air quality conditions can be achieved when, a large amount of different air conditioning units is used combined with suitable filters, fresh air exchange rates, higher indoor pressure environment and good overall maintenance of all systems. The present work aims at the study of the indoor air quality in selected important areas of the Greek ATCT complex.

METHODOLOGY

The under investigation tower is located in the urban area of the Athens city, close to the old main airport. It consists of six floors and four individual semi-detached buildings connected together with corridors. This building complex was initially completed in 1992, while from 1993 until 1997 indoor works took place installing ventilation systems, electronic and other building operation hardware. As from 1998 all operational programs were ready and in 1999 the Electronic- Technical Room started operating. Since than the only indoor modification was the instalment of the new wall to wall carpet three months before the measurement campaign. In the framework of the present research, it was decided to focus the investigation in certain parts of the tower complex, for which there were reported by the employs episodic indoor air quality cases and at the same time were of importance in respect to their use by the civil aviation authority. The under investigation areas presented certain peculiarities in comparison with other professional buildings that are studied previously. These include the following:

- The tower is extremely large with many sections that present significant differences in respect to the construction materials, use, type of work performed by the users and the air exchange conditions.
- The ventilation systems are different in the under investigation areas. In addition some places are completely isolated from the external environment while others are manually operated by the employs.
- In some places health symptoms were reported by the employs.
- The tower complex is close to many different external pollution sources, such as main roads, fuel storage, and until recently to the main airport run way.

Taking these into account it was decided to study as independent buildings the following five areas of the tower, (shown in figure 1):

1. The Approach Room, on the sixth floor.
2. The Technical Rooms, on the ground floor, (main electronics and small electronics rooms).
3. The Two Simulator Rooms, on the basement, (training and trainee offices rooms).
4. The AFTN Room, on the basement.
5. The Athens Flight Control Center, on the second floor.

The main steps followed for the indoor air quality evaluation were:

- Determination of area and pollution sources characteristics, (e.g. general building characteristics, main characteristics of all selected areas, building maintenance etc).
- Collection of data regarding possible employ health symptoms, (general symptoms, type of symptom and effect).

- Monitoring of VOC's concentrations inside the under investigation area, in the immediate outdoor environment and at the air inlets.

EXPERIMENTAL SET-UP

The experimental procedure for measuring the VOC's concentrations was based on the following methods and protocols:

- On the specially developed analytical methods for the sampling and chemical analysis of the VOC's, (Knoppel 1992; EPA 1988; NKB 1995; ECA 1997). These methods incorporate instrumentation that allows noiseless sampling of air where the organic compounds are absorbed by suitable agents which in turn are properly treated and analyzed in the laboratory using either flame ionization detector, (FID) or mass spectrophotometry, (MS) instrumentation or both. In the present case the sampling duration was set at 10 minutes intervals so that a good time resolution and a sufficient sample was achieved.
- On the air sampling and chemical analysis protocols that are developed on European level for the case of indoor air measurements and emissions of VOC's from building materials, (Clausen et al., 1993 and 1997; Lagoudi et al., 1994; and Bluyssen 1995). In accordance with these protocols, a large number of measurements should be taken in different parts of the building especially when the indoor environmental conditions differ from place to place within the same building.
- On the standard methods used on European and international level for dealing with the sick building problems, (Saarela and Sandel1991; Hodgon et al., 1991; Black et al., 1993; Bremer et al., 1993; and Rothweiler et al., 1993).

In accordance with the above, the following air sampling measurements were arranged:

- From the indoor environment of the pre-selected building areas.
- From the ventilation system.
- From the plenum underneath the floor of certain areas of the building.

Especially for the case of the indoor environment the air samples were taken close to the employ working positions at a height of 1.3 m above ground on the 19th of April 2001. The calibration measurements were systematically taken to guaranty an acceptable level of accuracy.

EXPERIMENTAL RESULTS AND DISCUSSION

The main sources of air pollution that were active during the course of the experiments can be summarized as follows:

1) Outdoor:

1. A high way road with dense traffic at a distance of 400 m.
2. A secondary runway for light air crafts at a distance of 500 m.
3. Aircraft service area at a distance of 700 m.
4. An out of use kerosene reservoir partially filled at a distance of 150 m.
5. An open 300 places car park at a distance of 30m.

2) Indoor:

1. Electronic equipment service, at the ground floor.
2. Canteen, at the basement.
3. Cleaning services, (desks and furniture, floor central vacuum cleaning, sweeping with chlorine and soap, etc.).
4. The main air inlets and pipes are not included in the cleaned procedure.

5. No main micro-bacteria sources were identified.
6. Smoking is allowed.
7. The main construction material is armed concrete without indoor plaster externally insulated.

As seen from the concentrations in many cases there are values that can not easily be explained by the general background pollution regime, thus indicating that both the ventilation system and very local pollution sources are responsible for the result. It is worth noting here that relatively low winds prevailed during the measurements with clear skies and average air temperature ranging between 16 and 17 C. The indoor temperature varied in the range of 21÷25 C. More analytically the following remarks can be made for the different sites of the sampling campaign:

Approach Room: As seen from the total VOC's values, (all chemical compounds), both the indoor and the plenum concentrations are significantly higher than the immediate out door ones. This clearly indicates the presence of indoor sources of pollution and possibly in sufficient ventilation of the room. It is worth noting here that this particular area is on the sixth floor of the tower, thus allowing for a better mixing of any external source of pollution.
The Technical Rooms: The same behaviour is also found in the case of the two electronic system rooms, (technical room on the ground floor), where the concentrations reach the value of 943 and 292 _gr/m3 in the middle of the large and the small electronic room respectively. Here again measurements of the VOC's concentrations at the ventilation inlet close to the ceiling are at least 20 times smaller, thus indicating that neither the external immediate environment nor the ventilation system itself is responsible for the indoor pollution.
The Simulator Room: The general picture in the case of the education simulator room at the basement throws some light on the indoor air pollution problem of the tower. In this case, a strong external source of pollution in the atria is identified. A careful inspection of this area showed that various construction materials and chemicals were left unattended for quite some time while the building envelope design did not really allowed proper natural ventilation. In the trainee offices room the situation is better since the air exchange with the atria is limited.
The AFTN Room: On the basement level, the AFTN room suffering from insufficient air refreshment gave the same picture like the simulator case. Here the indoor VOC's concentrations are significantly higher, (10 to 15 times), than the out door measurements.
The AFCC Room: Of particular importance for the ATCT operation is the AFCC room, (second floor), where the civil aviation officers have to be alerted through out their watch deciding on the air traffic. However the indoor VOC's concentrations are quite high and well above the out door and the plenum corresponding measurements. These values are many time higher than any recommended even for a chemical factory environment. All these observations clearly show that neither the air renewal nor the indoor room attendance is acceptable so that at least a similar to the out door environment regime to be created.

For practical purposes the VOC's total concentrations are presented graphically in figure 2. The main conclusions of the work can be summarized as follows:

- The indoor level of pollution are quite high considering that the suggested VOC's level for the European Union, (EU) is 200 _gr/m3 so that no symptoms on humans arise. This level is obviously exceeding all cases examined except the Approach room. It must be mentioned here that many VOC's chemical compounds, such as benzol are considered responsible for cancer so that their presence especially in the indoor environment at such levels should be avoided. In particular for the out door environment, the EU directive No. 2000/69/EU suggests 5 _gr/m3 as an acceptable mean yearly value.
- On the average the out door air as far as VOC's pollutants is concerned, is quite acceptable maintaining reasonable low levels.

- Extremely high concentrations of VOC's were found in the plenum, where the inlets for the simulation room are placed.
- The VOC's concentrations in the Approach room were not particularly high, because during the course of the measurements all windows were open.
- Considering the levels of indoor pollution the following rank among the different rooms was established: AFCC, Simulation, Technical, AFTN and Approach.
- All plenum VOC's measurements were lower than those of the indoor and higher than the out door ones. This also indicates that many sources of pollution exist in the rooms rather than the under floor areas.
- The main chemical compounds identified in the samples were Aromatics and Aliphatics of large molecular weight. Other chemical compounds were of polycycle compounds, terpene, alcohols, aldehydes and ketones.

TABLE 1

VOC concentrations in μg/m^3 during the measurement campaign. External stands for outdoor fresh air inlet n.d. stands for non-detectable level.

Sampling Pos. / Chem. Compound	Approach			Technical Elec/s		Sm. Elec/s	Simulator Education	Trainee	Atria	AFTN		AFCC		
	room	plenum	external	room	external	room				room	external	room	plenum	external
TVOC's	170	101	34	943	43	292	1258	372	4020	692	66	2600	1161	195
Aromatics	139	50	29	562	3	146	1250	364	3647	660	61	2061	931	195
Cycloids	nd	nd	nd	36	nd	3	nd	nd	8	nd	nd	50	59	nd
Terpene	2	1	nd	6	nd	10	nd	nd	17	nd	nd	13	10	nd
Aliphatics	20	6	1	100	nd	64	nd	nd	75	nd	1	200	33	nd
Alcohols	nd	nd	nd	98	2	4	nd	4	48	32	nd	11	8	nd
Aldehyde, Ketones and Acids	4	23	2	21	18	29	4	nd	89	nd	2	127	56	nd

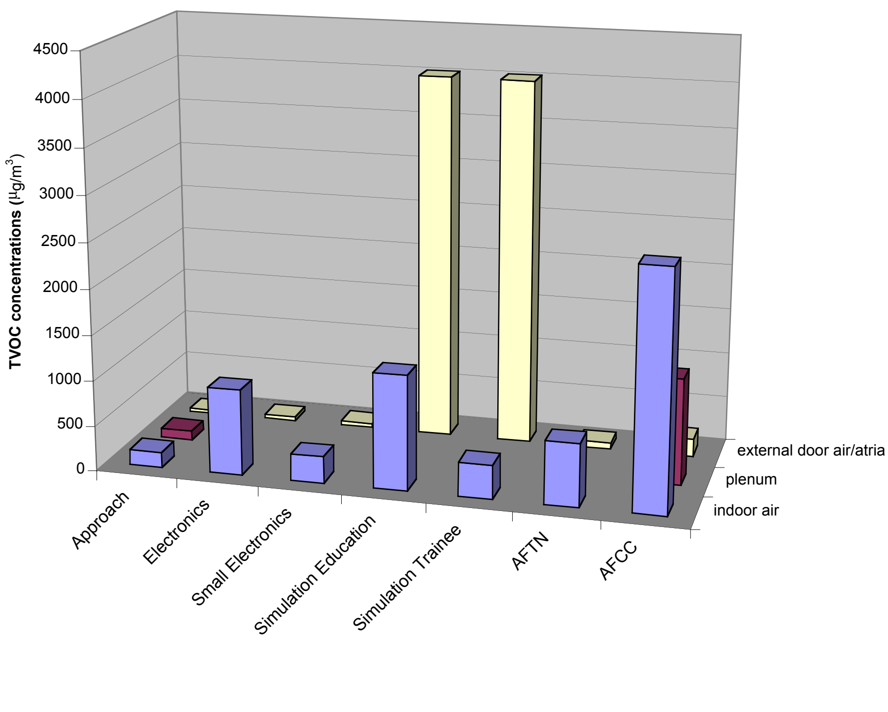

Figure 1: VOC average concentrations of the different rooms during the experimental campaign. It is noted that in the case of the simulator education room the external air stands for the atria.

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Acknowledgement

The Greek Aviation Authority and the University of Athens financially supported the present work. The authors would also like to thank Drs A.Lagoudi, C.Balaras, A.Argyriou and N.Pavlopoulos for their help during the course of the measurement campaign.